HVDC
Transformer Bushings
Type
GSETF/GSETFt

Mounting
Operating
and
Maintenance Instructions

SAFETY INSTRUCTIONS

These instructions are valid for mounting, operation and maintenance of transformer bushings type GSETF and GSETFt.

During mounting, operation and maintenance works there are a number of safety risks in the areas:

- Perilious electrical voltages
- High voltage
- Moving machines
- Large weights
- Equipment with internal gas pressure
- Handling of moving masses
- Injuries due to slipping, stumbling or falling

Regulations and instructions referring especially to these topics have to be obeyed when handling such equipment. Disregarding of the instructions may cause severe personal injuries, death, damages of products and materials or industrial injuries and/or consequential damages.

Beyond these rules national and internal safety instructions have to be followed.

In these instructions risks of personal injuries or death and product damage are marked with following signs near the texts and mounting steps:

Personal injuries or fatal damages

Industrial injury and/or consequential damages

These operating and maintenance instructions are valid for the types GSETF and GSETFt. For each bushing type these instructions are valid only together with the respective bushing specification, which contains all technical details and the dimension drawing. It is an integral part of these operating and maintenance instructions.

CONTENT

REMARK

In these operating instructions the design and the handling of HVDC transformer/reactor bushings is described. The only difference between the types GSETF and GSETFt is the type of filling underneath the composite insulator

GSETF	**SF_6-gas filling**
GSETFt	**dry filling**

1 Description

1.1 Construction

Connecting bolt fixed undetachably

Head armature

Silicone composite housing (silicone insulator)
Depending upon application and determination
- Design for hall operation (converter hall)
- Design for outdoor operation

Bushing flange with
- Test tap or voltage divider box
- Transformer/reactor air release screw
- Grounding bores
- Lifting eyes
- Gas connecting valve for type GSETF

External pressure control for type GSETF

Connecting box test/voltage divider

Metal bandage on earth potential

RIP inuslating body with capacitive grading

Terminal plate and connecting bolt

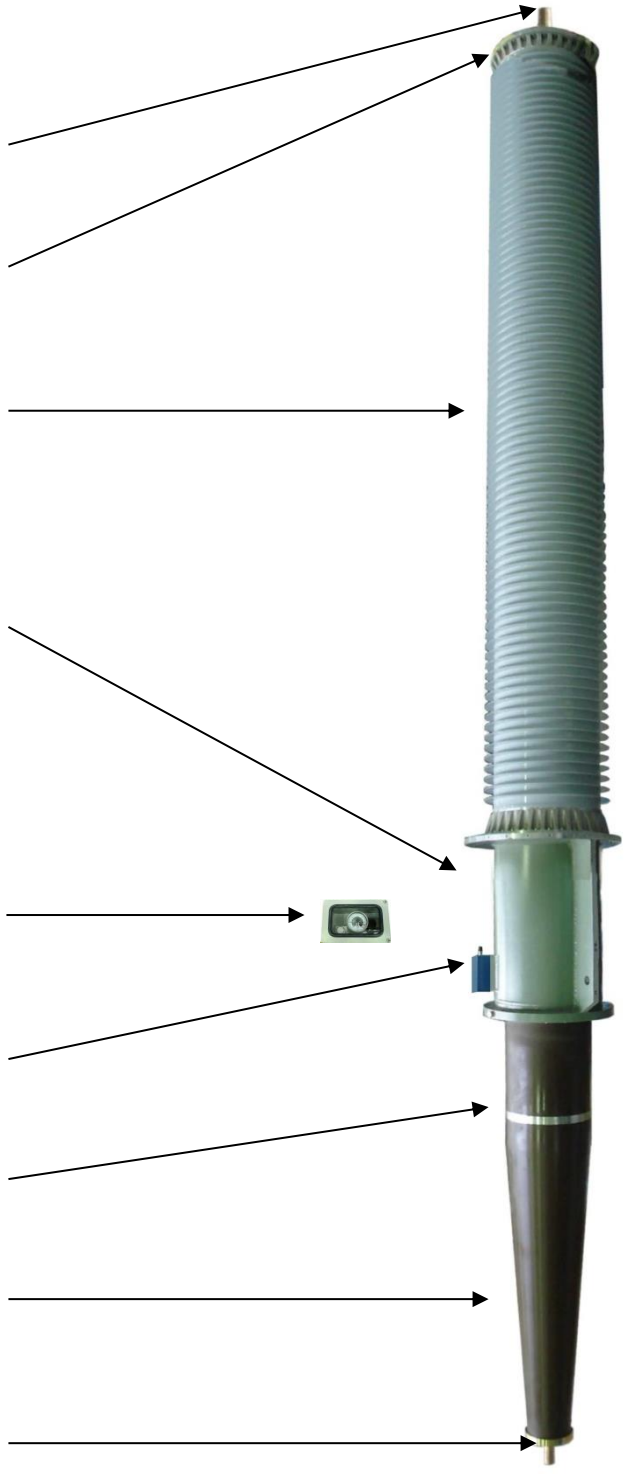

Fig.1

1.2 Design

The main insulation of the RIP bushing GSETF/t is the insulating body (7). It is made of a special paper which is impregnated with epoxy resin under vacuum and has coaxially and axially situated grading layers made of aluminium foil (8) which guarantee uniform voltage distribution along the insulating body. The end of the grounded last layer is additionally shielded with an external bandage (14) on the same potential as foot point for the DC-voltage part of the applied voltage.

The bushing has an undetachable conductor bolt (5) which is solidly fixed to the insulating body.

This unit is mounted in a silicone composite insulator (6). The silicone sheds and the flanges fixed by a special technique are directly vulcanized onto a fibre-glass re-inforced epoxy tube. In the bushing head there is an electrode (3) to support the external voltage distribution in the head area.

For the type GSETF the gap (4) between insulating body and composite insulator is filled with pressurized SF_6-insulating gas and an air release valve, which seals a circular ring chamber within the flange. Its purpose is to allow gas release in case of leaking sealings on the SF_6-side to prevent building of high gas pressure on the transformer side sealings.

For the type GSETFt the filling is made of a foamed polyurethane elastomer which causes a solid, flexible connection between the elements. Therefore it is not possible to disassemble these parts without destroying them.

The flange of the bushing (10) is fixed by screws to the bottom flange of the composite insulator (9). Its geometry is designed for the application of the bushing and depending upon the construction can be covered with an additional cylinder for better adaption to the wall opening in case of application in a hall.

The test tap with a voltage divider unit is located in a connecting box (12). As this bushing is operated with a mixed load, the divider unit is active for the AC-voltage part only. Above that there are grounding screws, air release bores, lifting eyes and the transformer ventilation (13).
For type GSETF there is an additional connecting valve (11) to which the gas pressure control device is connected via a tube system.

The head (2) of the bushing consists of a flange plate, which closes the composite insulator and devices to fix and seal the connecting bolt (1). Fixing points for the required head shielding's, which have a different design depending upon the connecting environment, are located in the flange plate.
For the type GSETF with gas filling there is an additional gas connecting valve.

The bottom plate (15) is undetachable fixed to the insulating body and at the same time seals the conductor bolt (16).
All sealings are designed as O-ring sealings. For the gas filled design the sealings, which seal the gas volume, are made of gas-resistant material, all sealings which are in contact with insulating oil are made of the oil-resistant material Nitril-Perbunan.

Contrary to AC-voltage bushings for these bushing types there is a DC-voltage loading. The grading characteristics of this bushing type are to a large extend depending upon its transformer or reactor side environment, which by means of a special barrier system (17) bears important functions of the grading. Therefore for each bushing type a barrier system designed exactly for each bushing type is required. The bushings can be replaced by bushings of exactly the same design only!

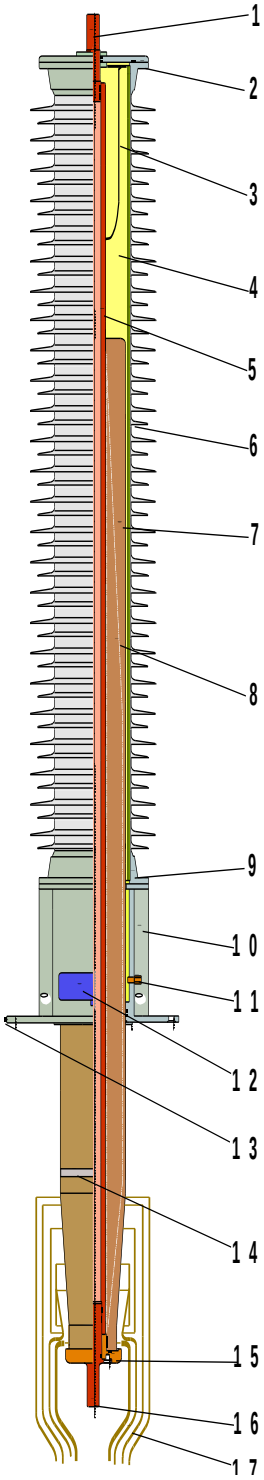

Fig.2

1.3 General Operating Conditions

Application:	Bushing for the installation on converter transformers and HVDC reactors in HVDC converter stations
Classification:	Epoxy resin impregnated paper, capacitive grading, transformer bushing
Ambient Temperature:	Hall bushings, airside: - 10°C up to + 50°C ** Outdoor bushings, airside: - 30°C up to + 40°C ** corresponding to temperature class 2 acc. to IEC 60137 Transformer side: Daily mean value + 90°C, max. value 100 °C **
Installation height:	< 1000 m a.s.l.**
Rain level and humidity:	for outdoor bushings: 1-2 mm rain/min. vertical and horizontal acc. to IEC 60060 – I **
Pollution class:	Corresponding to the specific creepage distance *** acc. to IEC 60815
Immersion medium:	Transformer oil acc. to the instruction of the transformer/reactor manufacturer
Max. oil pressure:	200 kPa excess pressure
Possibility to evacuate:	No restrictions regarding level and duration
Corrosion Protection:	All armatures and fixing materials are made of non-corrosive materials
Marking:	According to IEC 60137
Packing:	Bushing with transport protection cover, dry nitrogen filling and desiccant bags Wooden crate, ventilated, bushing on styro-foam supports at head and flange sealed in plastic foil with desiccant bags added.

** Standard values, deviations in special cases, see corresponding bushing specification
*** Standard: outdoor 50 mm/kV, hall 14 mm/kV related to Um(DC), deviations see bushing specification

1.4 Mechanical Stresses

Test bending load:	Standard acc. to IEC 60137 table 1, class II *
Operating load:	50% of the values of the test bending load *

* Standard values, deviations see corresponding bushing specification

REMARK:
Apart from these general operation conditions additional instructions of the transformer/reactor manufacturers and of the converter equipment have to be followed. For operation known rules from the AC-operation practise can be applied only to a limited extend.

2 Mounting

2.1 Status of Dispatch

Bushings type GSETF/GSETFt are supplied with transport protection tanks only for transport and storage. The tanks are filled with dry nitrogen and desiccant bags (Fig.3)

Fig. 3

The bushing is transported in a ventilated wooden crate (Fig. 4). It is supported by styro-foam cushions which are located at the head and at the flange. In case of bigger bushings the flange is additionally supported and fixed by wooden cross beams (Fig.5)

For storage resp. transport after operation/testing a connecting lead has to be guided from the connecting areas to the flange to short-circuiting of the condenser and avoid personal injuries.

Fig.4

The whole bushing is covered by plastic foil with desiccant bags added. In this packing the bushing can be stored in dry rooms covered by a roof for up to 24 months.

Long-term storage:
Long-term storage, e.g. for spare parts, can only be made when the transformer side end of the bushing is covered by a metal protection tank with gas or oil filling. (also see item 5)

Remark:
For the transport from HSP to the transformer manufacturer the protection cover is filled with nitrogen and desiccant bags only. Further transport to site is made with oil or nitrogen filling as determined by the transformer/reactor manufacturer. Both procedures are equally good.

Fig.5

2.2 Handling of the Bushing

The transport crate has to be moved at the marked lifting areas with transport and lifting devices. Transport is allowed in horizontal position only.

In case of bushings with gas filling gas pressure for transport is 20 kPa and is increased to operation pressure before putting the bushing into operation.

In order to remove the bushing from its crate it must be lifted and put down on the bushing head and on the flange only. Lifting it on the composite insulator may lead to a damage of the sheds, putting the bushing down on the insulator leads to deformation of the sheds.

Demounting of the transport protection cover must be done shortly be before installation of the bushing only. The surface of the insulating body (Fig. 2/6) is hygroscopic and absorbs moisture, which changes the resistivity behaviour under DC-voltage load. The surface must be no means subjected to rain directly. The installation instructions from the transformer/reactor manufacturer, which also concern the exposed barrier system during installation, have to be obeyed.

If bushings with traces of the influence of moisture are detected, they must by no means be installed. The manufacturer has to be contacted.
Depending upon the condition a drying procedure is possible, but this procedure has to be coordinated with the manufacturer.

For remote diagnosis make photographs of the whole transformer side end and also close-ups as shown on the left hand side and send them to the manufacturer.

On the left hand side comparative picture (Fig.6). In case moisture was absorbed the cellulose in the epoxy resin has a lighter colour.

The bushing must not be put down on the floor with its transformer side. Even in case of an upholstering there is the danger that in case of impacts invisible cracks occur in the insulation material and jeopardize later operation of the bushing.

Fig. 6

2.3 Lifting and Erection

For rising the lifting eyes have to be used. Depending on execution are scheduled at the bushing for two each or only one lifting points to establish the right axis situation of the bushing when having on already thus already. These lifting points already are in the status of dispatch assigned by her situation in the box. You are either enclosed as detachable lifting screws at the flange and/or head or provided depending on execution as lifting eyes attached directly to the flange.

The removable lifting eyes have to be removed after installation. The threaded bores have to be closed by the plastic covers.

The bushing is lifted with the help of two lifting devices allowing each requested inclination for installation (Fig.7/8).

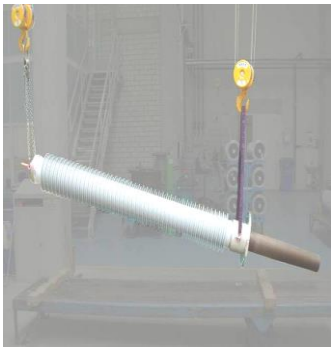

Fig. 7

Apart from that it is possible to lift the bushing with one lifting device only (Fig. 9 for example with 2 lifting points, each with two ropes, and Fig. 9a for example each with one lifting point, one rope).

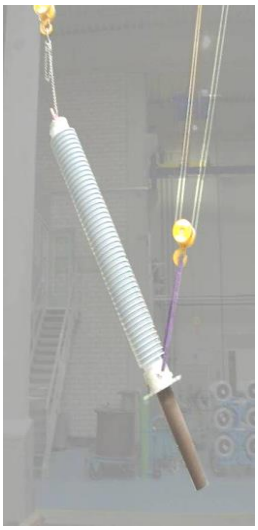

Fig. 8

To this a stop means of the crane hook is further led through the clevises at the bushing head to the bushing flange. Another stop means in form of either a block and tackle which also is put in at the crane hook or an electric rope traction which is fastened directly to the crane hook is led to the clevises at the bushing flange. With the block and tackle or the electric rope traction the lengths of the stop means are then adjusted so by attracting or desisting that the crane hook is over the balance point of the execution and the execution takes the desired slant position.

Remark: The execution has only one stop point each at head and flange only slant position is adjustably, an exactly vertical position can only with two stop points each to flange and head (on every bushing side).

Fig.9

Caution: Lengths of both parts, i.e. rope and pulley, have to be chosen in such a way, that the inclined tensile force for detachable lifting eyes does not exceed the permitted angle! (60° from the axial direction of the lifting eye)

With this procedure it is necessary to be extremely careful with respect to the insertion of the bushing into the sensitive barrier system, because precise adjustment of the insertion position is difficult.

In no case the bushing must be put down on the transformer side end for erection.

Fig.9a

2.4 Preparation for Mounting

After the bushing was removed from its packing it has to be put down on a pillow block at the flange and the head. The plastic foil is removed - do not use a knife because of the danger of damaging the silicone sheds.

Before the transport protection cover is removed the bushing should be fixed to the crane suspension by means of which it can be installed in the transformer/reactor afterwards immediately. If necessary the transformer side can be cleaned with solvent (e.g. Ethylacetat).

2.5 Mounting of the Bushing on the Transformer/Reactor

Mounting of the bushing is performed according to the handling procedure described in 2.3 and 2.4. Above that the instructions of the trans-former/reactor manufacturer have to be followed. This also applies to the torques to fasten the screw connections.

Fig. 10

2.6 Connections Monitoring Devices

On the transformer/reactor side the bushing is connected with the provided clamping armature or plug connections depending upon the type of design. The airside is connected by means of clamping armatures for the line connection or the wirings in the converter hall.

2.6.1 Connecting Box for Voltage Divider

On the bushing flange there is the connecting box for the voltage divider unit (Fig. 10). It contains a board with connecting terminals sealed against moisture. The wiring diagram (Fig. 11) with data for the individual wiring serves as example for a connecting configuration. As the voltage division by capacitors is tuned exactly to the bushing capacity to achieve the required output voltage, the data has always to be taken from the corresponding bushing specification. If this specification is not available, it can be ordered from HSP by quoting the serial number of the bushing.

In the status of dispatch the lead (Fig. 9/item 1) is connected with the terminal X3. It causes the firm grounding of the test tap and has to be left in this position, when no voltage is taken.
When the test tap is not connected during operation of the bushing a voltage occurs, which is equivalent to the partial capacities in the bushing. The level of this voltage is so high that the voltage resistance of the test tap insulation is not sufficient and permanently flashes over. This leads to a destruction of the insulation and an extension into the active insulation of the bushing and its destruction!

To take voltage the lead has to be put on terminal X0. The external voltage division with circuit Cz and R1 is activated.

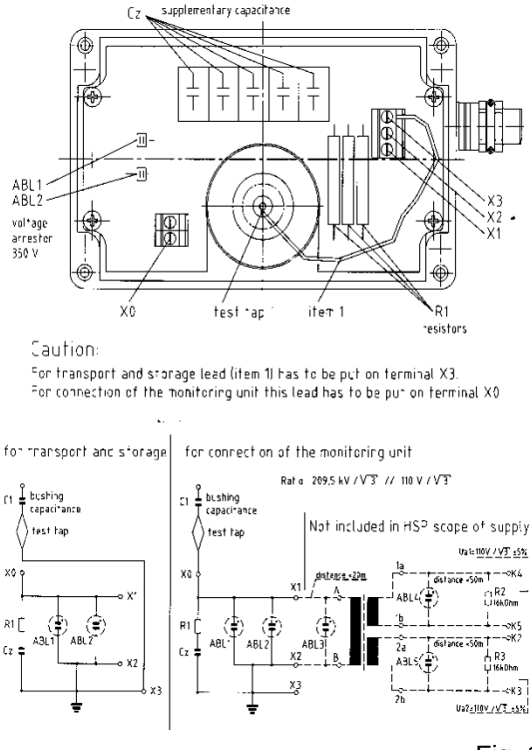

Fig. 11

2.6.2 External Pressure Control only for design with SF_6-gas filling GSETF

The condition of the gas filling is important for the functioning of the bushing. Gas leakage with a reduction of the pressure below the operating pressure of 1 bar excess pressure jeopardizes the operation of the bushing!

The monitoring and remote control is made by a contact manometer, which is installed in a separate, water-protected housing. Status of Dispatch: Fig.12/13 and Fig.14/16.

1 Housing with installed contact manometer
2 Soldered connecting union for connection tubing to the bushing
3 Connecting for the signal wiring
4 Gas connection with DILO-valve
5 DILO-valve counter part for refilling
6 Closing cap
7 Tubing (7 m, see Specification)

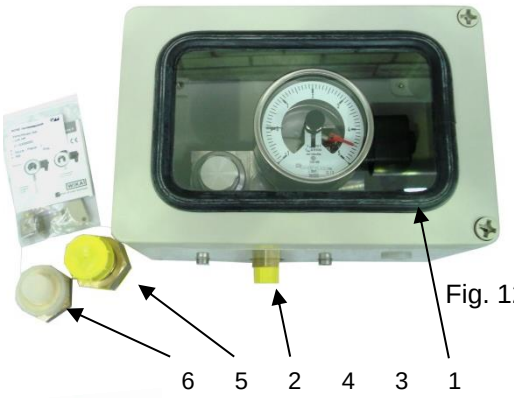

Fig. 12

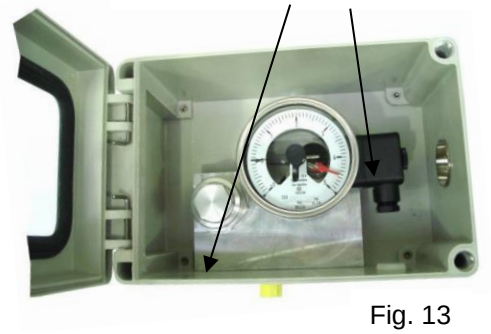
Fig. 13

The tubing for the connection to the bushing is soldered to the soldered connecting union. Take care that the tubing is installed protected against damages.

Via the gas connection (4) a pressure control for comparative measurement with the manometer data and refilling can be made.

The setting values for the contact manometer are different depending upon application and installation and related to the bushing.
As an example (Fig. 15) the specified data for a design type and its contact setting. It has always to be taken from the bushing specification. If the specification is not available, it can be ordered from HSP by quoting the serial number.

In its status of dispatch for transport reasons the bushing has a reduced pressure (20 kPa). Therefore after installation of the pressure control the gas pressure has to be brought to operating pressure according to specification by re-filling of additional SF_6-gas (see 2.6.3). In case the pressure control has not yet been installed connection can be made directly through the DILO-valve on the bushing (Fig 2/10).

The setting pressure is set according to the correction table below depending upon the ambient temperature of the bushing.

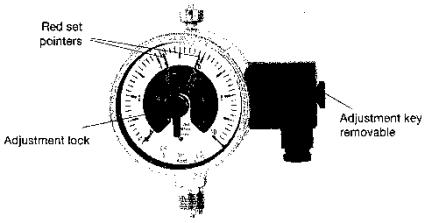

Fig. 14

Ambient temperature °C	Setting pressure for (kPa) bei 20°C)				
	260	280	300	320	340
0	235	254	273	291	310
5	241	261	280	298	317
10	248	267	286	305	325
15	254	274	293	313	323
20	260	280	300	320	340
25	266	286	307	328	348
30	372	293	314	334	355
35	278	299	320	342	363

In the status of dispatch the pressure gauge has no coordinate switching points.
The red set pointers for the alarm contacts are adjustable over the adjustment lock in the window with the aid of adjustment key (included in delivery) to be found on standard gauges on the outside edge of the junction box (Fig.14).
The red set pointers for the alarm contacts are adjustable over the full range of the instrument. Switching points shall be set in the ranges between 10% and 90% of the scale, to ensure switching accuracy and long life of the mechanical measuring system.

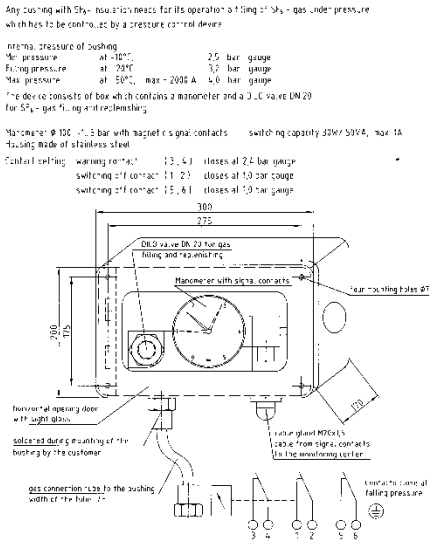
Fig. 15

Fig. 16

2.6.3 SF_6-Refilling and Release Unit

The equipment (Fig. 17) includes a pressure reducer unit (1) with setting handle and a manometer (3) for the pressure of the SF6 bottle and a manometer to set the pressure (4), a T-piece with angle-type non-return valve (5) and hose connection with 5 m pressure hose with DILO couplings DN 8 and DN 20 (optional)

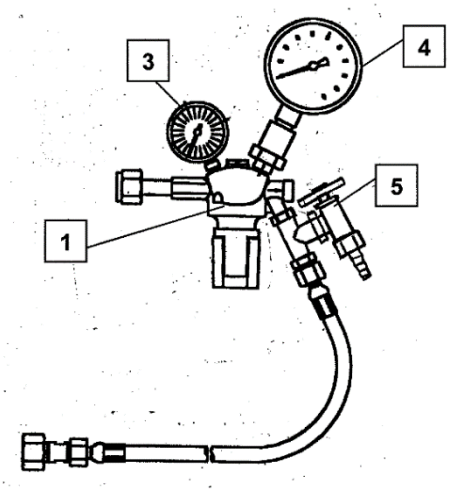

Fig. 17

Refilling of SF_6

The refilling equipment has to be connected to a common SF_6 gas bottle with new gas and the valve of the bottle has to be opened. The setting handle of the pressure reducer (1) has to be fully turned to the left, i.e. it has to be closed. In its status of dispatch the refilling device has a slight excess gas pressure to guarantee that no moisture can penetrate. This excess pressure should be kept after demounting of the device, approx. 50-100 kPa.

The valve coupling (DN8 or DN20) is connected to the bushing or to the monitoring unit. Prior to that the cap of the valve has to be removed. It is a non-return valve which opens only after the valve has been screwed to the re-filling device. On the display of the manometer (4) the pressure within the bushing can be read. After that the setting handle of the pressure reducer is opened until the required setting pressure is reached. Then the hose valve is separated from the bushing and the valve of the bushing is closed again.

Release of SF_6

When SF_6 is released take care that no gas is released into the environment. The gas has either to be collected in a suitable, pressure-resistant container (pressure-resistant up to 300 kPa, Vol. approx. 1m³) and after that to be let to a recycling installation (Fig. 16), or it has to be condensed in a recycling installation directly. The gas container or the recycling installation have to be connected to the hose connection of the non-return valve (5) with a pressure-resistant hose and the pressure has to be set by temporary opening and closing of the non-return valve.

Pressure to be set

For transport (road etc.) of the bushing the filling pressure of 20 kPa excess pressure must not be exceeded. Setting pressure and gas volume of the bushing are included in the respective specification. The gas density is 6.16 g/l at 20°C and 100 kPa abs. To estimate required gas quantities or quantities to be disposed of see table on the right hand side (Fig.18).

Mass depending upon pressure and volume at 20°C

Pressure abs. [kPa] \ Mass [kg]	Volume [dm³] 100	200	300	400	500	600	700	800	900	1000
100	0,6	1,2	1,8	2,5	3,1	3,7	4,3	4,9	5,5	6,2
110	0,7	1,4	2,0	2,7	3,4	4,1	4,7	5,4	6,1	6,8
120	0,7	1,5	2,2	3,0	3,7	4,4	5,2	5,9	6,7	7,4
130	0,8	1,6	2,4	3,2	4,0	4,8	5,6	6,4	7,2	8,0
140	0,9	1,7	2,6	3,4	4,3	5,2	6,0	6,9	7,8	8,6
150	0,9	1,8	2,8	3,7	4,6	5,5	6,5	7,4	8,3	9,2
160	1,0	2,0	3,0	3,9	4,9	5,9	6,9	7,9	8,9	9,9
170	1,0	2,1	3,1	4,2	5,2	6,3	7,3	8,4	9,4	10,5
180	1,1	2,2	3,3	4,4	5,5	6,7	7,8	8,9	10,0	11,1
190	1,2	2,3	3,5	4,7	5,9	7,0	8,2	9,4	10,5	11,7
200	1,2	2,5	3,7	4,9	6,2	7,4	8,6	9,9	11,1	12,3
210	1,3	2,6	3,9	5,2	6,5	7,8	9,1	10,3	11,6	12,9
220	1,4	2,7	4,1	5,4	6,8	8,1	9,5	10,8	12,2	13,6
230	1,4	2,8	4,3	5,7	7,1	8,5	9,9	11,3	12,8	14,2
240	1,5	3,0	4,4	5,9	7,4	8,9	10,3	11,8	13,3	14,8
250	1,5	3,1	4,6	6,2	7,7	9,2	10,8	12,3	13,9	15,4
260	1,6	3,2	4,8	6,4	8,0	9,6	11,2	12,8	14,4	16,0
270	1,7	3,3	5,0	6,7	8,3	10,0	11,6	13,3	15,0	16,6
280	1,7	3,4	5,2	6,9	8,6	10,3	12,1	13,8	15,5	17,2
290	1,8	3,6	5,4	7,1	8,9	10,7	12,5	14,3	16,1	17,9
300	1,8	3,7	5,5	7,4	9,2	11,1	12,9	14,8	16,6	18,5
310	1,9	3,8	5,7	7,6	9,5	11,5	13,4	15,3	17,2	19,1
320	2,0	3,9	5,9	7,9	9,9	11,8	13,8	15,8	17,7	19,7
330	2,0	4,1	6,1	8,1	10,2	12,2	14,2	16,3	18,3	20,3
340	2,1	4,2	6,3	8,4	10,5	12,6	14,7	16,8	18,8	20,9
350	2,2	4,3	6,5	8,6	10,8	12,9	15,1	17,2	19,4	21,6
360	2,2	4,4	6,7	8,9	11,1	13,3	15,5	17,7	20,0	22,2
370	2,3	4,6	6,8	9,1	11,4	13,7	16,0	18,2	20,5	22,8
380	2,3	4,7	7,0	9,4	11,7	14,0	16,4	18,7	21,1	23,4
390	2,4	4,8	7,2	9,6	12,0	14,4	16,8	19,2	21,6	24,0
400	2,5	4,9	7,4	9,9	12,3	14,8	17,2	19,7	22,2	24,6
410	2,5	5,1	7,6	10,1	12,6	15,2	17,7	20,2	22,7	25,3
420	2,6	5,2	7,8	10,3	12,9	15,5	18,1	20,7	23,3	25,9
430	2,6	5,3	7,9	10,6	13,2	15,9	18,5	21,2	23,8	26,5
440	2,7	5,4	8,1	10,8	13,6	16,3	19,0	21,7	24,4	27,1
450	2,8	5,5	8,3	11,1	13,9	16,6	19,4	22,2	24,9	27,7

Fig. 18

To read manometers recording in „bar“ use 1 bar = 100 kPa

Remark: SF6 is not toxic, but heavier than air and can accumulate in holes or valleys. As a result oxygen is displaced and staying in this atmosphere can lead to suffocation.

3 Putting into Operation

3.1 General Measures

Before putting the bushing into operation with the help of the check list on the right hand side (Fig. 19) it has to be checked that all steps have been carried out correctly. Taking into consideration application in DC voltage operation and/or mixed voltage operation this control seems to be appropriate.

3.2 Ventilation of the Bushing

The bushing can be evacuated at the flange. The ring gap between the flange edge and the oil filling of the transformer cover is desired. As a rule the transformer side oil volume is filled under vacuum, i.e. no desairiation is required. Desairiation of the current conductor is not possible and required due to its design.

3.3 Evacuation of the Transformer/Reactor

There are no restrictions regarding duration and level of vacuum for the evacuation with respect to the bushing. The temperature should not exceed 90°C.

3.4 Recommended Tests before putting into Operation

- Visual check of the bushing with respect to damages of the silicone composite housing
- Correct fastening of the head shielding
- Correct connection in the voltage divider box
- For type GSETF with gas filling check of the correct setting pressure
- Leakage control in case of GSETF with SF_6 leakage detector
- Dew point measurement to determine the moisture condition of the gas filling
- All screws tightly fastened

CHECK LIST		
	Description	Reference see
1	Tranport protection cover was removed shortly before installation of the bushing.	2.2
2	Check for damages and condition of the surface of the insulating body (scratches, pollution, moisture)	Fig.6
3	Check for damages of the silicone composite housing; no damages during removal of the plastic packing	2.4
4	Observation of the ambient conditions during installation of the bushing in the transformer/reactor	2.2
5	No irregularities during insertion of the bottom part of the bushing into the barrier system (impact on the edge of the flange etc.)	2.3
6	Current conductor connection o.k. plug contact/clamping connection	2.3
7	Torques observed for mounting of the flange	2.5
8	Correct fitting and position of the shielding for the bushing head	
9	Correct wiring and connection of the voltage divider unit	2.61
10	If no external connection to the voltage divider unit is made, correct grounding of the test tap	2.61
11	For type GSETF with gas filling control of the correct lead of the tubing, correct soldering connection to the soldered connection union	2.62
12	Correct pressure setting acc. to ambient temperature in case of gas filling and according to bushing specification	2.62
13	Dew point measurement to check the moisture condition of the gas filling	3.41
13	Check of the setting values of the switching contacts on the manometer in the external pressure control	2.62
14	Connecting valves for later pressure control or re- filling available	2.6.2
15	Final varnish o.k.	

3.4.1 Dew Point Measurement

(Only for bushings type GSETF with SF_6-gas filling)

The gas filling of the bushing has to be dry, therefore it is necessary to carry out a dew point measurement to determine moisture before putting the bushing into operation.

It is recommended to carry out this test before the gas pressure is increased to the operating value. Thus the moisture condition in status of dispatch is determined. If it is not correct, drying can be achieved by flushing's. After that the pressure is set with dry SF_6. After increase of the pressure the dew point has to be determined again and entered into the commissioning report of the transformer/reactor.

Dew point measurements are carried out with corresponding devices, the measuring probe of which has to be placed in the flowing gas stream. As gas has to be refilled in any case, a mobile gas-recycling installation is an obvious choice, into which the gas of the bushing is returned by using the refilling and release equipment (Fig. 2.6.3, Fig. 17). To this tube the measuring value recorder is connected to carry out the measurement in the released gas stream.
As an example for a mobile gas recycling device see (Fig. 20).

Fig.20

The dew point of the bushing gas should be -5°C at 20°C ambient temperature.

In case of other temperatures the corrective factors have to be considered which can be taken from the files of the measuring equipment used.

Example for a mobile dew point measuring device (Fig.21).

Fig.21

4 Maintenance

4.1 Recommended Maintenance and Control

A difference has to be made between bushings, the air insulation of which is in a converter hall and bushing for outdoor use, e.g. in case of reactors.
Permanent maintenance of the bushing is not required. During the maintenance intervals of the installation the condition of the silicone composite insulator of the bushing has to be check visually (pollution, discharge traces).

In case discharge traces are found the reasons have to be looked for and, if necessary, the bushing manufacturer has to be contacted.

As for bushings with gas pressure monitoring a permanent control is provided, it is recommended to check the function and display of the manometer during general maintenance intervals and to ensure their effectiveness.
Bushings which are in operation in converter hall do not require cleaning of the insulator surface, because there is no pollution from the environment.
Bushings which are installed outdoor may require cleaning, though. Especially in case of DC-voltage stress due to polarisation irregular pollution may occur.

4.2 Cleaning of the Insulator Surface

The insulator surface should not be cleaned regularly. Its good features regarding pollution are temporarily influenced by cleaning, because on its surface there is a water-repellent coating, which is temporarily removed by cleaning.

Cleaning is done with cloths free of fluffs and well soaked with cleaning agent. The silicone sheds are flexible therefore no big force can be applied, but light force more frequently instead.

Cleaning agent: Wacker E10 of Messrs Wacker Chemie, purchase unit 25 ltr., consumption 1 ltr. for approx. 3-5 m^2 of surface.

After cleaning the features return to their original condition after approx. 1-2 days.

An approximate statement about the condition of this so-called hydrophobicity is the HC-classification shown (Fig.22).

For testing purposes during wind still and dry weather an area of the size of a hand has to be sprayed properly with water from a spray bottle from a distance of approx. 30 cm. The display of the drops has to be compared with the HC-table.
Up to class HC3 it can be assumed that the features are sufficient for the place of installation.

But this is only a rough comparative procedure. The results do not provide any guarantee for the operating behaviour.

In addition the insulator should be checked visually for possible discharge traces. Such traces must not occur, because they damage the surface of the insulator in this area with respect to hydrophobicity. In such a case the cause for the discharges has to be determined.

Real damages of the sheds or on the body, like shearing for example, cannot be repaired on site. In case of small damages repair may be possible and has to be agreed upon with the manufacturer first.

Possible larger remainders of paint can be pulled off after drying – do not use solvents!

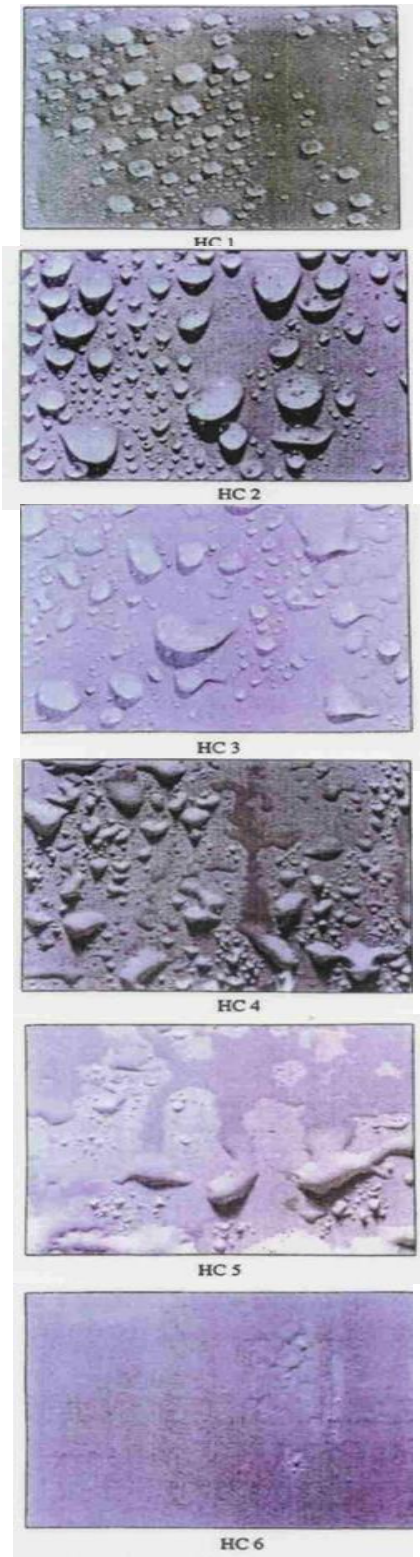

Fig.22

4.3 Electrical Measurements

The bushing is tested and certified as suitable for operation by the final routine test in manufacturer's factory and by the final test of the transformer/reactor.

We recommend electrical measurements of the bushing to guarantee suitability for operation after the first 7-10 years of operation and after that depending upon the test results in intervals of 3 years or shorter.

During measurements on site with a test voltage of 12 kV bushing capacitance and tan delta are determined. The bushing capacitance is an indicator for the condition of the main insulation. In case of partial punctures between the grading layers capacitance changes. The degree of change provides information about the number of grading layers effected.

A permanent monitoring of bushings with mixed voltage load is provided by the voltage divider as well. The divider ratio changes when the bushing capacity changes.

Control measurements on bushings require a certain experience with measuring equipment, test set up and interpretation of test results. For some part this is a result of the relatively small capacitance values, which are locally influenced by the environment. The measurement of the dielectrically dissipation factor can be influenced by humidity, weather etc.

Remark regarding electrical measurements on bushings for mixed and DC-voltage

On site measurements are possible, but the interpretation of the measurement results is difficult and very complex, as comparative values can be used only to a limited degree. Therefore it is recommended to contact the manufacturer in any case. The methods and data given provide only a rough overview.

Example for mobile measuring equipment

Fig.23

4.4 Measuring Procedures

Mainly the measuring procedures differ by the coupling of the measuring signal. In case of so-called "not grounded" measurements the test voltage is applied to the conductor of the bushing and the measuring signal is taken at the test tap of the bushing.
The "grounded" measuring procedure for bushings without test tap is not applicable for bushings of type GSETF/t.
The devices required for measurement are usually equipped specifically for the measurement of bushings. The measurements methods are described in comprehensive manuals.

4.5 Equipment

Measuring equipment is available from several manufacturers. Data can be taken from the internet or enquired at HSP (Fig.23).

4.6 Limits

For measurements the influence of the ambient temperature has to be taken into account. In the diagram on the right hand side for C and tan delta the variation through temperature is shown. (Fig.24)

For the material RIP, resin impregnated paper, there are limit values for the deviation of the capacitance and the dielectric dissipation factor with relation to the „new value“ (Fig.25). This value is reliably deducted from the reference measurement, which was made either during the final routine test of the transformer/reactor or which is carried out as first measurement after min. every 2 years.
In case the deviation is higher than mentioned in the table below, HSP should be contacted in any case

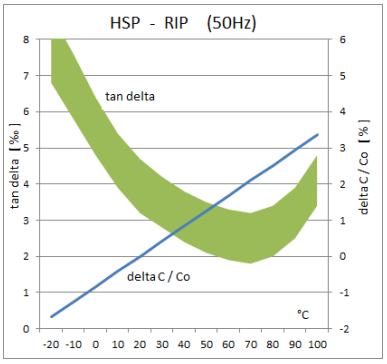

Fig.24

4.7 Thermo-Control with Thermovision

If thermovision control is carried out as a routine in the installations, following items have to be taken into account for the GSETF/t bushings.
An increase of temperature up to 40 K can as a rule be detected at the external contact point, i.e. at the lead clamp and is not unusual. Higher temperatures or excess temperatures during low load should lead to a check of the contacts (Fig.26).
Irregularities in the temperatures along the outdoor insulator length, though, may be caused by hotspots and have to be investigated more closely, if necessary contact the manufacturer.

ORIENTATION VALUES

Rated voltage* (Line-Line AC+DC or DC)	C-Deviations
< 400 kV	3%
> 400 kV	1%

tan delta 0.004 – 0.006
*see bushing specification

Fig.25

5 Storage

Bushings of this type are always supplied with a transport protection tank. Therefore long term storage providing dry atmosphere in the protection tank (also see 2.1) is possible. We recommend filling with dry N2 (0,25bar gauge). At regular intervals this pressure must be checked at the manometer and, if necessary, resqueezed.

Alternative the tank has a screw through which it is filled with insulating oil, 7% less than the total volume as compensation volume in case of temperature variations. This type of long-term storage has the advantage that checks are limited to visual checks for leakages.

The pressure in the SF_6 gas volume of the bushing type GSETF has to be checked every 3 years, in case of pressure loss above 20% related to a temperature of 20°C gas has to be refilled.(Correction factors see table 2.6.2)

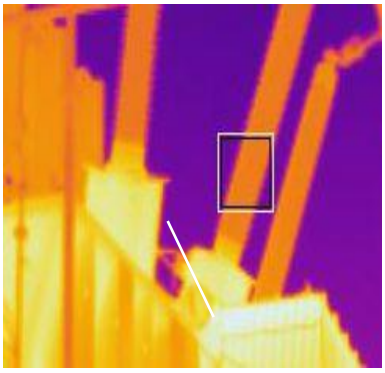

Fig.26

6 Repair Possibilities

Repair is possible in case of:

Leakages of gas filled bushings type GSETF
Investigation in case of internal failure and possible repair

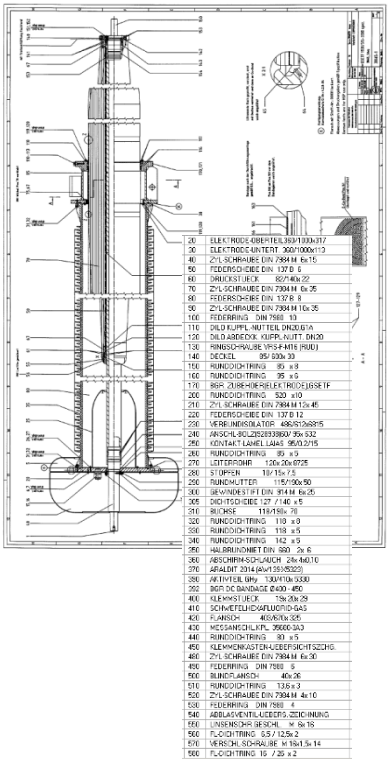

Fig.27

In case of the design with dry filling GSETFt repair is restricted to the parts accessible from outside, because due to the construction disassembly of the composite housing is not possible.

The design with gas filling GSETF allows disassembly of the composite housing.

These operating and maintenance instructions are valid for both types, therefore in case of a repair different sectional drawings and parts lists for explanation for the mounting steps are necessary. If the case occurs the documents can be ordered from HSP by quoting the specification number of the bushing (Example of a sectional drawing and a parts list, Fig.27). Above that depending upon repair requirements corresponding short instructions can be given.

<u>General measures in case of repair</u>

a) Type GSETFt with dry filling:

Disassembly is not possible. Therefore repair is restricted to external damages of the silicone sheds, which are possible in case of smaller damages by means of special measures. They can be carried out according to the instructions of HSP or by HSP.

In case of internal failures the composite insulator has to be destroyed to allow access to the internal construction parts. We recommend returning the bushing to the manufacturer, who has suitable means and measures and the professional investigation methods.

b) Type GSETF with gas filling:

The sealings in the bushing head can be replaced when the bushing is installed. For works which involve the disassembly of the composite housing we recommend to demount the bushing. This mounting has to be carried out in a dry and clean room, because the SF_6 -filled inner volume of the bushing has to remain free of dust.

In case of internal failures the bushing has always to be demounted. All parts can be disassembled. By loosening the screw connection on the bushing head the cover (Fig 2/2) can be disassembled, the composite insulator can be disassembled after loosening the screw connection on the flange.

In this case the procedure described under a) is recommended, contact HSP. Investigations on site can be carried out by HSP service personnel.

7 Disposal after End of Operation

The bushing does not contain liquids, the parts are neither toxic, self-inflammable nor physically stressing.

Following components:

- Silicone elastomer
- Fibre-glass re-inforced epoxy resin
- Polyurethane elastomer (dry filling)
- Epoxy resin impregnated special paper with aluminium foils as layers
- Central tube and armatures made of aluminium Alloy
- Draw lead and conductor bolt made of E-Cu
- Fixing elements, test tap, screws etc. made of non-corrosive steel, aluminium alloy or brass

For type GSETF with gas filling in addition the rules for handling, recycling and disposal of SF_6 insulating gas have to be obeyed.

As the insulating body of type GSETFt is undetachable connected to the composite housing by dry filling material, it is recommended to cut the bushing above and underneath the flange, as well as the head and the composite housing several times for better disposal.

8 Info Scheme Places of Installation

For better understanding of possible places of installation of bushing type GSETF/t see Fig.28.

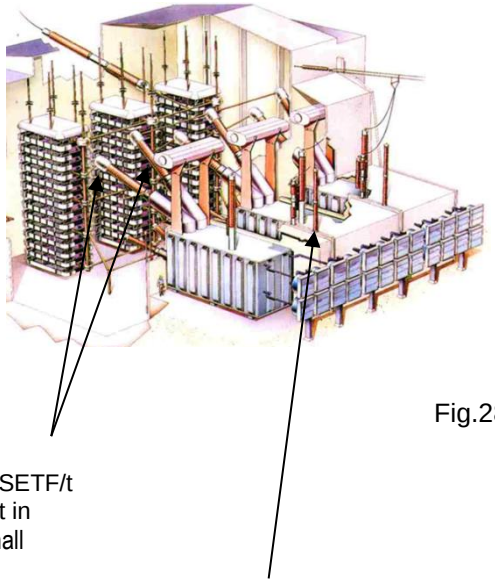

Fig.28